MORTALITY OF HERPETOFAUNA, BIRDS AND MAMMALS DUE TO VEHICULAR TRAFFIC IN ETAWAH DISTRICT, UTTAR PRADESH, INDIA[1]

K.S. Gopi Sundar[2]

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[2]Wildlife Institute of India, P.B. 18, Chandrabani, Dehra Dun 248 001, Uttaranchal, India.
Present Address: Indian Cranes and Wetlands Working Group, C/o International Crane Foundation, E-11376, Shady Lane Road, Baraboo, WI-53913, USA and C/o Wildlife Protection Society of India, M-52, Greater Kailash Part-I, New Delhi 110 048, India. Email: gopi@savingcranes.org

Roadkills of herpetofauna, birds and mammals were enumerated along a 20 km stretch of road in Etawah district, Uttar Pradesh, in an agriculture dominated area. A total of 133 kills of 33 species of animals were recorded over two years. Amphibians and birds were killed significantly, more during the monsoon, while reptiles and mammals were killed almost equally across seasons. The species killed the most were the Marbled Toad *Bufo stomaticus* (amphibia), Flapshell Turtle *Lissemys punctata* (reptile), House Crow *Corvus splendens* (bird) and domestic Dog *Canis familiaris* (mammal). When all species present along the road for the taxa were considered, bird species were least represented in roadkills (16%), and higher proportions of species were killed in the other taxa (25-30%). Amphibians and birds were killed significantly more in the monsoon, while season did not affect numbers of kills for herpetofauna or mammals. Medium sized birds and omnivore bird species were killed the most. Accounting for all bird species present, number of birds of different sizes killed was in proportion to that present along the road. When guilds were considered, omnivore species were killed in much higher proportion to their availability along the road. No taxa of conservation concern was killed by traffic during this study. No species or taxa was killed to an extent that would endanger the species, though specific studies on species most vulnerable to vehicular traffic will be useful to determine how to prevent such mortalities.

Key words: Frequency of roadkills, herpetofauna, birds, mammals, *Bufo stomaticus*, *Lissemys punctata*, *Corvus splendens*, *Canis familiaris*

INTRODUCTION

Roads have been known to cause ecological effects like fragmentation, habitat loss due to deforestation, affect animal movement, cause changes in animal behaviour, and cause mortality due to accidents with vehicular traffic (van der Zande *et al.* 1980; Fahrig *et al.* 1995; Goosem 1997; Forman and Alexander 1998; Trombulak and Frisswell 2000; Develey and Stouffer 2001; Serrano *et al.* 2002). Vehicles on roads are thought to have overtaken hunting as the leading direct human cause of vertebrate mortality (Forman and Alexander 1998), often endangering local populations of common and threatened species (Clarke *et al.* 1998; Hódar *et al.* 2000; Huijser and Bergers 2000). In 1994, India had 3 million km of road, of which 50% were surfaced (Rajvanshi *et al.* 2001). In Uttar Pradesh alone, a total length of 1,21,761 km had been added in 1998-99 (Anon 2001). The direct or indirect impact of these roads on wild fauna has received very little attention in the country.

There is general awareness of the prevalence of mortality due to vehicular traffic of free-ranging vertebrates in India, and reports of such mortality are increasing (Dhindsa *et al.* 1988, Sharma 1988, Gokula 1997, Kumara *et al.* 2000, Rajvanshi *et al.* 2001, Vijayakumar *et al.*2001). These studies have either listed kills (Sharma 1988, Gokula 1997, Rajvanshi *et al.* 2001), or addressed concerns to fauna in protected areas with special reference to effect of habitat on patterns of roadkill (Vijayakumar *et al.* 2001), and season on select fauna (Kumara *et al.* 2000). Few studies have explored community structure of vulnerable taxa along roads in an agricultural landscape in an effort to understand the potential species that may be affected by vehicular traffic (Dhindsa *et al.* 1988). Most of these studies have concentrated on mammals and herpetofauna, and reports on bird mortality due to vehicular traffic are few (Dhindsa *et al.* 1988, Sharma 1988). None of these studies have information on the proportion of species in an area affected by vehicular traffic. I studied some aspects of faunal mortalities due to vehicular traffic in Etawah district, Uttar Pradesh, in north central India. The study investigated the following questions.

1. What species of herpetofauna, birds and mammals are most affected by vehicular traffic and what proportion of species present are represented in roadkills?
2. Is faunal mortality due to vehicular traffic similar across seasons?
3. Are all avian groups present along the road (species, families, sizes, guilds) affected equally by vehicular traffic?

STUDY AREA

The study was carried out along the main road starting at Etawah town (26° 48' 51" N, 78° 59' 32" E) and ending at

Saiphai town (26° 57' 51" N, 78° 57' 52" E), on a stretch of road measuring 20 km. The road was metalled, a two-way traffic route with equal width throughout, and was busy since it was the only connecting road between Etawah and Mainpuri towns. Most of the heavy traffic was at night when buses plying northwards and trucks carrying cargo used the route. Daytime traffic comprised principally of tractors, smaller four-wheelers (cars, jeeps), and two-wheelers (scooters, motorbikes, mopeds). Speeds of the vehicles were as high as 110 kmph for four-wheelers, while two-wheelers reached speeds of 70 kmph. Three counts of vehicles, one each in summer, monsoon and winter, between 0730-0845 hrs in 2000 showed that an average of 56 vehicles ply every hour on the road with no significant difference in number of vehicles across seasons (χ^2_2=1.52, p>0.09).

Both sides of the road were bordered almost continuously with dry scrub and trees, behind which were crop fields, groves with fruit trees or habitation. Major trees along the road were *Dalbergia sissoo*, *Ficus benghalensis*, *Syzygium cumini*, *Mangifera indica*, and *Psidium gujava*, and the predominant shrubs were *Prosopis juliflora* and *Ipomoea aquata* with *Saccharum* sp. grass growing in few places. In addition, six village ponds of varying sizes, eight small (<10 ha) grassy marshlands, one alkaline wasteland, nine small towns (<ten houses each) and nine large towns (>ten houses each) bordered this stretch, and one small river and two canals intersected it. Only three village ponds were perennial due to disposal of sewage into them, while the rest were full only during and immediately after the monsoon, drying up in January/February. The region was thus suitable for a variety of fauna.

Three principal seasons could be differentiated based on rainfall and temperature regimes namely, winter (November-February), summer/ pre-monsoon (March-June) and monsoon (July-October). The main crops beside the stretch of road were barley, fruits, and paddy during May-November, and wheat and vegetables during November-April. In late June and early July, most fields were fallow until the rains. The main source of precipitation was the southwest monsoon with an annual average of 851 mm (1990-2002, District Collector's Office, personal communication), and fog/ dew in winter. Temperatures varied between 1 °C in winter to >45 °C in summer.

METHODS

Road kills were recorded for two years during January 2000 - December 2001. The road was patrolled one to six times a week between 0600-1000 hrs each sampling day driving at 20-35 kmph. Presence of highwaymen prevented evening and nighttime sampling. Effort was more or less constant over months and years. Every animal found killed due to vehicles was identified to the level possible and removed to avoid repetition. Most kills recorded were fresh with the complete animal available for identification. Only twice, kills of birds were ascertained from feathers left over by scavengers. To determine the number of species present along the road, opportunistic observations were maintained and all animals were identified to the species level. For mammals, bats were not considered. This enumeration is likely to be a minimum since many nocturnal species could have been missed. For birds, all species were classified into five size classes (very small, small, medium, large, very large), and grouped into eight feeding guilds (aquatic, carnivore, frugivore, granivore, insectivore, nectarivore, omnivore, and scavenger, as per Ali and Ripley 1989), and noted if they crossed the road. Statistical analyses were restricted to ascertaining if frequency of kills of individual taxa were different across seasons using χ^2 tests. Comparisons across taxa were not carried out since differences in removal rates of different sized animals, differential mortalities during day and night, and seasonal and species differences in densities of the various taxa were unknown and not controlled for. Bias due to the unaccounted animals which may have been struck by vehicles, but crawled away has not been corrected. It is known that speeds of vehicles, intensity of traffic, the kind of vehicles, width of the road, habitat conditions etc. also affect mortality (Dhindsa *et al.* 1988, Goosem 1997, Finder *et al.* 1999, Clevenger *et al.* 2003); these biases have also not been investigated or controlled for during this study.

RESULTS

Frequency of roadkills

The road was monitored for 226 and 230 days in 2000 and 2001 respectively, covering a total of 9,120 km. A total of 21 amphibians (three species, two families, rate of kill: 0.0023/ km), 34 reptiles (six species, four families, rate of kill: 0.0037/ km), 46 birds (17 species, 12 families, rate of kill: 0.005/km), and 32 mammals (seven species, four families, 0.0035/km) were recorded as roadkills (Table 1). Family Bufonidae was represented the most in amphibian kills (13/21), with the Marbled Toad *Bufo stomaticus* being killed most frequently (9/21). Among reptiles, the Flapshell Turtle *Lissemys punctata* was killed the most (10/34) and equal numbers of the families Boidae and Colubridae were killed (9/34 each). Among birds, species from four families, Corvidae, Sturnidae, Ardeidae and Rallidae, were killed the most (69% of 46 kills, Table 1). The House Crow *Corvus splendens* (n=6) and cattle egret *Bubulcus ibis* (n=5) were killed most frequently. In the family Sturnidae,

Table 1: Frequencies of roadkills of herpetofauna, birds and mammals in Etawah, Uttar Pradesh, India (January 2000 to December 2001)

Sl. No.	Taxa	No. of individuals (% of total)
	AMPHIBIANS	
I.	**Family Bufonidae**	**13 (61.91)**
	1. *Bufo melanostictus*	4 (19.05)
	2. *B. stomaticus*	9 (42.86)
II.	**Family Ranidae**	**8 (28.57)**
	3. *Hoplobatrachus tigerinus*	3 (14.29)
	Unidentified ranids	3 (14.29)
III.	**Unidentified frogs**	**2 (09.52)**
	Total	**21**
	REPTILES	
I.	**Family Boidae**	**9 (26.47)**
	1. *Eryx johnii*	9 (26.47)
II.	**Family Colubridae**	**9 (26.47)**
	2. *Xenochrophis piscator*	3 (08.82)
	3. *Oligodon sp.*	1 (02.94)
	4. *Ptyas mucosa*	5 (14.71)
III.	**Family Agamidae**	**1 (02.94)**
	5. *Calotes versicolor*	1 (02.94)
IV.	**Family Testudidae**	**10 (29.41)**
	6. *Lissemys punctata*	10 (29.41)
V.	**Unidentified reptiles**	**5 (14.71)**
	Total	**34**
	MAMMALS	
I.	**Family Canidae**	**23 (71.88)**
	1. *Canis familiaris*	19 (59.38)
	2. *C. aureus*	3 (09.38)
	3. *Vulpes benghalensis*	1 (03.13)
II.	**Family Felidae**	**5 (15.63)**
	4. *Felis chaus*	1 (03.13)
	5. Domestic cat	4 (12.50)
III.	**Family Herpestidae**	**3 (09.38)**
	6. *Herpestes javanicus*	3 (09.38)
IV.	**Family Sciuridae**	**1 (03.13)**
	7. *Funambulus palmarum*	1 (03.13)
	Total	**32**

Sl. No.	Taxa	No. of individuals (% of total)
	BIRDS	
I.	**Family Picidae**	**1 (02.17)**
	1. *Dinopium benghalense*	1 (02.17)
II.	**Family Upupidae**	**1 (02.17)**
	2. *Upupa epops*	1 (02.17)
III.	**Family Coraciidae**	**3 (06.52)**
	3. *Coracais benghalensis*	3 (06.52)
IV.	**Family Centropodidae**	**3 (06.52)**
	4. *Centropus sinensis*	3 (06.52)
V.	**Family Psittacidae**	**2 (04.35)**
	5. *Psittacula krameri*	2 (04.35)
VI.	**Family Rallidae**	**5 (10.90)**
	6. *Amaurornis phoenicurus*	5 (10.90)
VII.	**Family Ardeidae**	**7 (15.20)**
	7. *Bubulcus ibis*	5 (10.90)
	8. *Ardeola grayii*	2 (04.35)
VIII.	**Family Corvidae**	**10 (21.80)**
	9. *Corvus splendens*	6 (13.04)
	10. *C. macrorhynchos*	4 (08.70)
IX.	**Family Sturnidae**	**9 (19.60)**
	11. *Sturnus pagadorum*	1 (02.17)
	12. *S. contra*	3 (06.52)
	13. *Acridotheres tristis*	4 (09.70)
	14. *A. gingianus*	1 (02.20)
X.	**Family Cisticoliidae**	**2 (04.35)**
	15. *Prinia inornata*	2 (04.35)
XI.	**Family Sylvidae**	**1 (02.17)**
	16. *Turdoides malcolmi*	1 (02.17)
XII.	**Family Passeridae**	**2 (04.35)**
	17. *Passer domesticus*	2 (04.35)
	Total	**26**
	Total kills	**133**

all four species present in the area were represented in kills. Among mammals, the Family Canidae was represented most in roadkills (23/32), with Dogs *Canis familiaris* being killed the most (19/32). Among wild species, Jackals *C. aureus* and small Indian Mongoose *Herpestes javanicus* were killed the most (3/32 each), and one kill each was recorded of the Fox *Vulpes benghalensis*, Jungle Cat *Felis chaus* and Palm Squirrel *Funambulus palmarum* (Table 1).

Species richness along the road was the lowest for herpetofauna and the highest for birds (Table 2). At the family level, the representation in roadkills varied widely across taxa with most of the amphibian families present being killed and very few of the mammal families present being represented in roadkills (Table 2). At the species level, except for birds that had a very small proportion of species present along the road being killed (16%), the other taxa were very similar in terms of proportion of species represented in roadkills (25-30%, Table 2). Of the species present along the road, all species of

Table 2: Species richness of herpetofauna, birds and mammals found along the road and as roadkills in Etawah, Uttar Pradesh, India (January 2000-December 2001)

Taxa	Number present		Number seen in roadkills (proportion of total)	
	Families	Species	Families	Species
Amphibians	3	10	2 (67)	3 (30)
Reptiles	10	24	4 (40)	6 (25)
Birds	40	104	12 (30)	17 (16.4)
Mammals	15	24	4 (29)	7 (27)

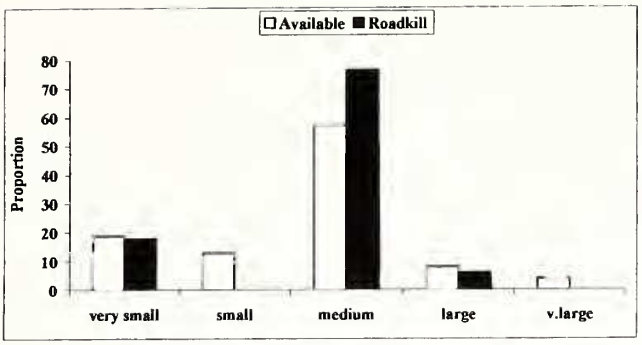

Fig. 1: Effect of body size on vulnerability of birds to traffic in Etawah, Uttar Pradesh, India

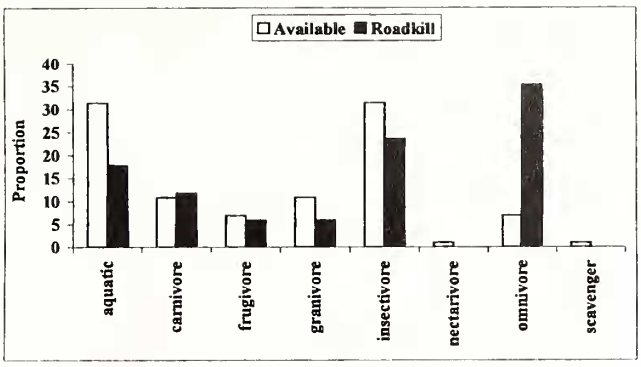

Fig. 2: Representation of guilds of birds along the road and in roadkills in Etawah, Uttar Pradesh, India

amphibians and mammals were seen to cross the road at least once. Among the reptiles, 16 of the 27 species seen along the road (66.6%) were seen to cross the road at least once and for birds, 89 of the 104 species listed along the road (85.6%) were seen to cross the road at least once at a height that would render them vulnerable to be killed by vehicles. All species represented in roadkills were from this list.

Effect of season of frequency of roadkill

There was no significant inter-annual difference in the rate of kills, or number of species killed for any taxa (χ^2_1 test, $p>0.1$ in all cases) and kills were pooled seasonally. Sufficient data for seasonal analyses each year was available only for birds. Amphibians were killed disproportionately more in the monsoon ($\chi^2_2=14$, $p<0.001$, Table 3) while reptiles and mammals were killed in nearly equal numbers in all seasons (χ^2 tests, $p>0.1$). While birds were killed in nearly equal proportions across seasons in 2000 ($\chi^2_2=5.33$, $p>0.05$), a significantly high number were killed during the monsoon in 2001 ($\chi^2_2=16.7$, $p<0.001$). For the pooled information, significantly more birds were killed during the monsoon ($\chi^2_2=18.57$, $p<0.005$). The least kills for amphibians, reptiles and mammals were in summer, while birds were killed the least during winter (Table 3).

Effect of size and guild on frequency of roadkills of birds

All the bird species represented in road-kills were resident and diurnal. Most birds killed were of medium size (76.5%, Fig. 1). Very small and medium sized birds were represented in roadkills in nearly the same proportions as those present along the road, while small and very large birds were not killed (Fig. 1). Most kills were of omnivore (35.3%), insectivore (23.5%), and aquatic species (17.7%, Fig. 2). Omnivore species were killed in far higher proportion than present along the road, while insectivore and aquatic species were killed in lesser proportions (Fig. 2). To examine effect of size and guild on vulnerability of birds to vehicular traffic, sample sizes obtained were too small to carry out statistical analyses.

Table 3: Seasonal effect on frequency of roadkills of herpetofauna, birds and mammals in Etawah, Uttar Pradesh (January 2000-December 2001)

Taxa	Number killed		
	Summer	Monsoon	Winter
Amphibians	2	15	4
Reptiles	11	7	16
Birds	10	29	7
Mammals	8	12	12

DISCUSSION

Herpetofauna

Very few kills of amphibians were obtained and most of them were during the monsoon. However, these animals are small and carcasses on roads do not probably last very long on the road, and the estimates obtained during this study must be taken to be a minimum. An increase in mobility and activity of amphibians due to rains leads to their increased mortality due to vehicular traffic (Vijayakumar *et al.* 2001). Vijayakumar *et al.* (2001) recorded much higher rates of roadkills for both amphibians (2/km) and reptiles (0.4/km) than this study, but these were obtained from a forested area. There are no studies on roadkills of herpetofauna in the country from non-forested on non-protected areas to compare the results of the present study. Traffic does not seem to be a major concern for amphibians in Etawah. In Mudumalai, Gokula (1997) found more kills of snakes during the daytime as compared to evenings and nights. Vijayakumar *et al.* (2001) found no influence of rain on mortality rates of reptiles, as was recorded by this study. Kumara *et al.* (2000), however, found a significant positive relationship between the rainy season and number of reptiles killed, particularly uropeltid snakes. When uropeltids were considered separately, other snakes showed no relationship between mortality rates and

rainfall, similar to that found in Etawah. Many species of reptiles that are strictly arboreal such as the geckos and those restricted entirely to canals and rivers such as the hard-shelled turtles were found along the road but were not represented in roadkills. Monitor lizards *Varanus benghalensis* and *V. flavescens* were seen killed in other roads in the area, but not represented on the study road.

Amphibians are clearly more susceptible to mortality by vehicular traffic during the rains due to increased activity, most likely related to breeding. However, most reptiles killed in Etawah were in the winter. The dark surfaces of the roads usually retained heat much later than the soil possibly attracting reptiles. Kills of *B. stomaticus*, *E. johnii* and *L. punctata* were very high and specific studies on these species may be worthwhile to ascertain exact causes and reduce or even prevent such high mortalities.

Birds

This study suggests that mortality due to vehicular traffic affects only a small proportion of species in an area, medium-sized birds are affected the most, omnivore and insectivore species are more vulnerable than species belonging to other guilds, and most kills occur during the monsoon. It appears that vehicular traffic causes minimal mortalities of birds, and is unlikely to be a matter for concern. Numbers of birds of each species were much lower in roadkills compared to actual numbers along the road. Majority of the species present crossed the road implying that the road is not perceived as a barrier by most bird species and that almost all the birds are vulnerable to vehicular traffic. The rate of roadkills of birds recorded in this study, however, was far lesser than that recorded for a similar habitat type in Rajasthan, about 200 km west of the study site. Sharma (1988) recorded a total of 219 kills of 26 species of 19 families in one year in a stretch of five km of road. He found that the Eurasian Collared Dove *Streptopelia decaocta* was killed the most in Rajasthan but was never represented in roadkills in Etawah. In Rajasthan, aquatic birds were killed the least, but the globally threatened sarus crane *Grus antigone* was represented in kills. The rate of roadkills was 0.12 kills/km (calculated from the study assuming that sampling was carried out for 365 days), 24 times higher than that recorded during this study. There was, however, no information on the species composition of the bird community along the road. The bird community structure is likely to be similar with Etawah, and it is interesting that different results were recorded. Vegetation structure, traffic intensity, and other factors such as fallen grain on the road etc. may have contributed to the differences in patterns of roadkills.

In Etawah, presence of few fruiting trees along the road caused large amounts of ripe fruits to be available on the road during the fruiting season and resulted in the deaths of mynas and crows foraging on fallen fruits. Crows were further killed when they were scavenging roadkills. The only rallid represented in kills, the White-breasted Waterhen *Amaurornis phoenicurus*, was found living in roadside ponds. Kills could have occurred either during foraging events or during territorial fights with conspecifics. The author nearly ran over one individual which was engrossed in an aggressive interaction with another bird in the middle of the road, and when the motorbike was near them, broke away quite unpredictably and ran towards the motorbike. Several passerines were also seen to engage in territorial disputes, an activity that would make them more vulnerable to approaching traffic. The Greater Coucal *Centropus sinensis* was seen to be a nest predator and often carried away eggs and nestlings from nests alongside the road. One kill each was recorded in May, September and November of this species. Many species of birds were seen nesting along the road during these months.

The Lesser Golden-backed Woodpecker *Dinopium benghalense* and Rose-ringed Parakeet *Psittacula krameri* usually foraged on tree trunks and in the canopy respectively and were correspondingly under represented in road kills. The sole *D. benghalense* killed during the study was found near the entrance of a termite colony from which alates were emerging. The bird had flown down to feed on the alates fleeing the colony, as was confirmed by its stomach contents. *P. krameri* deaths occurred when flocks were chased off from adjoining fields while they were depredating crops. The two parakeets found killed had large quantities of wheat in their stomachs. Occasionally, individuals were seen foraging on fallen fruit of *F. benghalensis* and *P. gujava* on the road and this may lead to deaths occasionally. Ardeids take a longer time to attain height when they take off as compared to other bird species. After taking off from marshlands and ponds adjoining the road, they tended to fly low over the road making them susceptible to speeding traffic. Though White-necked Storks *Ciconia episcopus* and Sarus Crane *Grus antigone* nested along the road on trees and wetlands respectively, these large waterbirds were not killed by traffic during the study period. Food on roads and specific behaviour (e.g. territoriality) at certain times seem to be responsible for kills of birds on roads. Additional species that were found killed due to traffic on other roads near the study road but not represented in this study were the White-throated Kingfisher *Halcyon smyrnensis*, *Streptopelia decaocto*, *Grus antigone*, and Red-vented Bulbul *Pycnonotus cafer*.

Mammals

Of the seven species of mammals found killed in the study, none were of conservation concern. One species,

F. palmarum, was arboreal and the rest were ground dwelling. Both the Fox and the Jungle Cat were killed during the night. The other nocturnal animals that were seen along the road were the Striped Hyaena *Hyaena hyaena*, Common Palm Civet *Paradoxus hermophroditus*, and Indian Pangolin *Manis crassicaudata* but were not killed by traffic during the study. These animals were sighted in the early morning. One Pale Hedgehog *Paraechinus micropus* was found killed by traffic after the completion of the study. Previous accounts of roadkills on mammals in India have been restricted to protected and forested areas and have documented deaths of many species of conservation concern (Kumara *et al.* 2000, Rajvanshi *et al.* 2001). Kumara *et al.* (2000) found no influence of either habitat type or season on rates of mortality of mammals in a protected area, quite similar to the patterns observed in Etawah. Mammals had relatively low mortality rates in summer. The region along the road was particularly dry in summer months and mammals may have moved away at this time. Most of the deaths (6/8) observed in this season were of domestic animals (dogs, n=4, cats, n=2) lending some credence to this surmise.

Implications of the study

This study suggests that mortality rates due to vehicular traffic is quite low for all the taxa studied, and that populations of most species may not be significantly affected by roadkills due to traffic. No species of conservation concern was killed by traffic during this study. The results of this study are in contrast with those obtained from other regions in the country. Roads in agricultural areas do not seem to be causing large-scale mortalities of vertebrate fauna. However, many more studies away from protected and forested areas are required to ascertain the actual magnitude of roadkills in relation to populations of particular species. Studies elsewhere have documented that roads perform as physical barriers to movements of animals often changing their behaviour (Daveley and Stouffer 2001), and that animal densities are affected by the presence of roads (Fahrig *et al.* 1995, van der Zande *et al.* 1980). The overall disturbance effect of roads on wildlife would therefore be underrepresented by roadkills and animals are possibly affected much more by other effects of roads such as habitat fragmentation, stress due to noise of traffic etc. (van der Zande *et al.* 1980, Goosem 1997, Forman and Alexander 1998). Considering that the Government of India is undertaking several large-scale expansions of the road network in Uttar Pradesh and in the rest of the country, many more studies are required before we can hope to better understand the impact of roads on wildlife in the Indian countryside.

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